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Novel MEC based Approaches for Smart Hospitals to Combat COVID-19 Pandemic

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***Abstract*—COVID-19 or Coronavirus has thrilled the entire world population with uncertainty over their survival and well-being. The impact this pathogen has caused over the globe has been profound due to its unique transmission features; that urges for contact-less strategies to interact and treat the infected. The impending 5G mobile technology is immersing the applications that enable the provisioning of medical and healthcare services in a contact-less manner. The edge computing paradigms offer a de-centralized and versatile networking infrastructure capable of adhering to the novel demands of 5G. In this article, we are considering Multi-Access Edge Computing (MEC) flavour of the edge paradigms for realizing the contact-less approaches that assist the mediation of COVID-19 and the future of healthcare. In order to formulate this ideology, we propose three use cases and discuss their implementation in the MEC context. Further, the requirements for launching these services are provided. Additionally, we validate our proposed approaches through simulations.**

I. INTRODUCTION

Wold Health Organization (WHO) has declared COVID-19 outburst as a pandemic considering its rapid dispersion and the level of contagiousness. A causative agent for COVID-19 has not been identified yet; but specifies the virus as a form of pneumonia of unknown etiology [1]. This pathogen is targeting the respiratory system and the transmission is conducted through respiratory droplets or aerosol emissions. The health officials around the globe are experimenting on a possible cure. Though, an effective and safe treatment or a cure has not being identified yet. Thus, controlling the spread of the infection and mediating the infected with therapeutic strategies are the approved practices for mitigation.

During the span of January to July 2020, the infected populous has been accumulating exponentially along with the casualties. The amount of infected personnel and resources allocated for treating them are creating issues for governments. In addition, establishing quarantine facilities and maintaining them withers the resources in terms of monetary and man-power perspectives. More importantly, the lack of knowledge on the cause of the pathogen and its transmission exposes the health care officials while treating the infected. This is a vital conundrum for most nations where the hospital medical care and treatment protocols are designed and practiced via human-to-human interaction. Thus, COVID-19 is leading the future of healthcare towards contact-less treatment strategies with technological engagement.

The novel requisites for e-Health type applications align with IoT service requirements of ubiquitous connectivity to cater data aggregation of wearable devices, Augmented Reality (AR) based surgery, and Virtual Reality (VR) based surgical training applications [2]. In addition, epidemic or pandemic threats of COVID-19, Ebola-2015, MERS-CoV-2012, H1N1-2009, and SARS-CoV-2003 have urged for robotic influence in the medical care and daily hospital activities; that can contribute in the areas of clinical care, logistics, and reconnaissance. In order to cater all these novel technologies, Ultra-Reliable Low-Latency Communication (URLLC) capabilities are pertinent for controlling robotic appliances, enhanced Mobile Broadband (eMBB) based audio/video patient monitoring, aggregating medical data, and notifying health officials on their schedules and emergency situations. Prevailing cloud computing based service infrastructure however, is not adequate to launch these envisioned directives. The geo-distributed placement of cloud servers and weaker access capacity inherited with standalone Base Stations (BSs) are creating bottle-necks in traffic flows at various points in the mobile network [3]. These limitations are enforcing an unintended latency and jitter on network nodes. Thus, URLLC and eMBB specifications demanded by robotics and AR applications are infeasible with the prevailing networks. The concept of edge computing, which offers communication, storage, processing, and networking capabilities within a proximate operating range is an ideal solution for such a circumstances [4]. On the contrary, edge paradigms are promisingly adopted for healthcare directives with prolific success over cloud based systems [5], [6].

Multi-Access Edge Computing (MEC) is a leading edge computing paradigm introduced by the European Telecommunications Standards Institute (ETSI) for the purpose of provisioning cloud computing capabilities at the mobile BS in proximity to the accessing User Equipment (UE) [7]. This emerging concept is one of the pillars in pragmatically launching the fifth generation (5G) mobile technology; that reforms the prevailing mobile network architecture towards a softwarized core and a backhaul network. The heterogeneity envisaged by the plethora of Internet of Things (IoT) devices in addition to the service guarantees of up to 10 Gbps data rates, 1 ms round-trip delay, 99.999% availability; that perceive 100% ubiquitous connectivity are stipulating the deployment of 5G and its related technologies of URLLC, eMBB, and massive Machine-Type-Communication (mMTC) for the prospective future.

The one of the main intentions of 5G is to launch micro or macro scale BSs for delivering specialized services with featured URLLC capability. In the prospect of considering health services in a hospital vicinity as a specialized service, a MEC enabled In-building Base Station (IBS) can be placed in the premises. The compatibility and inter-operability features of MEC ensures the interfacing of myriads of medical sensory devices and their protocols towards a centralized data centre. Highly dynamic and virtualized service provisioning platform of the MEC IBS will allow servicing diverse healthcare applications with real-time performance. The orchestrator functionality at the MEC IBS, Mobile Edge Platform Manager (MEPM); guarantees the proper distinguishing of various services, scalable access to all IoT medical devices with improved link capacity, and maneuvering the storage and processing resources to mediate the seamless operation.

Therefore in this paper, we are proposing a MEC based edge computing approach to satisfy the intrinsic technological requisites demanded by the novel contact-less and remote medical procedures for treating COVID-19 patients within a medical facility. This work extends the reach of MEC towards adaptability established by [8], assures the claims proposed by [9], [10] to mitigate COVID-19, and validates the utilization of edge computing in IoT systems as conceptualized in [11], [12] with MEC; while improving the feasibility of smart health solutions proposed in [2], [13], [14]. The Section II introduces three futuristic use cases that effectively establish contact-less operation, while the methodology to realize these initiatives with MEC is presented in Section III. Section IV validates the proposed use cases with MEC, while Section V discusses various challenges in relation to realizing these proposals. Section VI concludes the article.

II. MEC ENABLED USE CASES

MEC enabled IBS deployed at medical institutions contrives an IT ecosystem for digitizing the holistic medical infrastructure. In this section, three plausible use cases are discussed with reasoning. As illustrated in Fig. 1, our proposed use cases are sharing the digital infrastructure of the MEC IBS. These use cases are attributed with contact-less capabilities that enhance the accuracy and management of healthcare operations for optimal performance. Further, various communication and networking parameters required for realizing the proposed use cases on their primary goals/ applications are introduced in TABLE I.

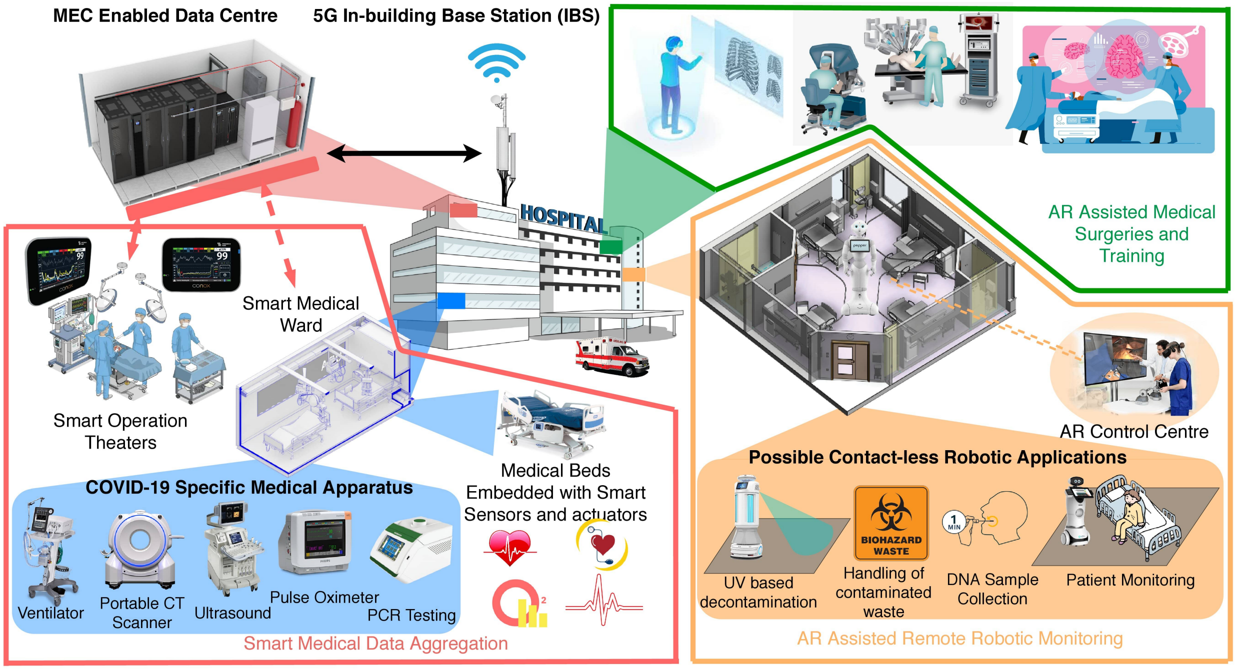


Fig. 1: MEC based Health Services for COVID-19 Pandemic

A. *Use Case 1 : Augmented Reality (AR) based Remote Robotic Monitoring*

Most observed fact during the first half of 2020 was, health officials including the physicians been infected rapidly, while treating the patients regardless of the extremely secure protective gear being worn by them [18]. This is impacting the health workforce directly. Thus, it is evident that measures should be taken to remotely monitor and treat the patients in a controlled environment to mitigate the infections towards health personnel. Variety of remote monitoring approaches are followed at present through robotics and sensory acquisitions aggregated via sensors placed in medical wards. Augmented Reality (AR) offers a novel approach into reaching the patients with Remotely Operated Vehicles (ROVs) or robots that interfaces robotic entanglements with improved precision than typical remote operations [19]. As illustrated in Fig. 1, AR operated robots can be used for: surface decontamination through ultraviolet (UV) emission, delivery and handling of toxic or bio-hazardous waste, collection and testing of nasopharyngeal and andoropharyngeal swabs, and patient monitoring with delivery of minor treatments. These functions cover majority of the daily routine work that medical staff personnel are engaging.

B. *Use Case 2 : Smart Medical Data Aggregation/patient monitoring and treatment*

Monitoring the vitals of COVID-19 patients rapidly leads to the automated and accurate commandeering of medical treatment devices; that is critical for the fast recovery and survival of the infected people. Further, medical apparatus such as Polymerase Chain Reaction (PCR) testers, pulse oximetry measuring scope (that leads to NEWS2 and PEWS early warning scores), ventilator, and chest imaging (radiograph, CT, lung ultrasound) are intrinsic within a COVID-19 treatment facility according to the WHO treatment protocol [20]. Therefore, the smart and sophisticated medical wards embedded with remotely operable medical apparatus are required to early detection and treatment of COVID-19 in addition to protecting the medical staff from the exposure. If the medical bed itself comprises the intrinsic measuring and treating devices in them (as seen from Fig. 1), medical officers can operate the bed remotely while contacting the patient via audio and video communication. This digitized infrastructure with multitude of electronic devices are forming a mMTC environment that demands communication links with a formidable level of capacity and continuous connectivity. In addition, aggregation and visualization of medical data from a remote and a centralized hub is vital for early diagnosis of the level of COVID-19; where the treatment plan for the patient is determined accordingly.

C. *Use Case 3 : AR Assisted Remote Surgery*

There are tendencies to adapt AR for remotely operated surgeries in addition to visualizing internal organs externally to improve the invasive medical procedures with enhanced precision. Further, Haptic feedback approaches can be induced to AR applications; where kinaesthetic communication is practiced with touch or motion based perception is conveyed to the user for enhancing the feedback retrieval through additional human-sensory adaptions. The requirement for a Robot Assisted Surgery (RAS) arises with emergency situations where a qualified surgeon is not available within the premises, or the possibility for surgical staff to be exposed to a pathogen while performing the surgery; which constitute to a COVID-19 circumstance. American College of Surgeons identified the surgeries of rupture tubal-ovarian abscess, tubal-ovarian abscess not responding to conservative therapy, emergency cerclage, Cancer or suspected cancer, and Cerclage of the cervix as plausible RASs [21]. These AR based RASs are demanding eMBB, mMTC, and URLLC requirements with higher processing and communication resources.

TABLE I: Requirements on the networking perspective for realization of the proposed use cases [15]–[17]

Use Cases / Primary Applications	Requirements							
	End-to-End Latency	Jitter	Packet Loss Rate	Bandwidth/ Bit rate	Availability	Max. # of UEs	Serving Area (m^2)	Security Level
Use Case 1 : AR Controlled Robotic Monitoring								
Stereoscopic 4K (3840x2160 pixels) 120 fps real-time video stream with lossless compression	🟩 < 2 ms	🟥 $< 10\mu s$	10^{-3}	🟥 > 24 Gbps	🟩 >99.99999%	1	100	MEDIUM
4K 120 fps real-time video stream with lossless compression	🟨 < 50 ms	🟨 < 2 ms	10^{-3}	🟩 > 12 Gbps	🟩 >99.99999%	10	100	MEDIUM
Robot Telemetry / Motion control data stream	🟩 < 2 ms	🟨 < 2 ms	10^{-4}	🟨 > 16 Mbps	🟥 >99.999999%	10	100	MEDIUM
Haptic Feedback data stream	🟩 < 2 ms	🟨 < 2 ms	10^{-4}	🟨 > 16 Mbps	🟥 >99.999999%	1	100	MEDIUM
Use Case 2 : Smart Medical Data Aggregation and Monitoring								
Physical vital signs monitoring data stream	🟨 < 250 ms	🟨 < 30 ms	10^{-4}	🟨 > 1 Mbps	🟨 >99.999%	20	10^8	HIGH
CT/ MRI scan data	🟨 < 1 s	🟨 < 30 ms	10^{-4}	🟨 > 240 Mbps	🟨 >99.99%	20	10^8	HIGH
Uncompressed 512x512 pixels 20 fps video stream from ultra-sound probe	🟨 < 50 ms	🟨 < 30 ms	10^{-4}	🟨 > 160 Mbps	🟨 >99.99%	20	10^8	HIGH
High quality audio stream	🟨 < 100 ms	🟨 < 30 ms	10^{-2}	🟨 > 128 Kbps	🟨 >99.99%	20	10^8	MEDIUM
Stereoscopic 4K 60 fps color coded real time video monitoring	🟨 < 250 ms	🟨 < 30 ms	10^{-3}	🟩 > 2 Gbps	🟨 >99.99%	20	10^8	MEDIUM
Use Case 3 : AR based Remote Surgery								
Uncompressed 4K 120 fps real-time video stream	🟥 $< 750\mu s$	🟥 $< 10\mu s$	10^{-4}	🟥 > 30 Gbps	🟩 >99.99999%	1	100	MEDIUM
3D 256x256x256 voxels 10 fps ultrasound unicast data stream	🟨 < 10 ms	🟥 $< 10\mu s$	10^{-3}	🟩 > 4 Gbps	🟨 >99.9999%	1	100	MEDIUM

🟨 Capabilities of Pre-5G 🟩 Capabilities of General 5G 🟥 Capabilities of MEC enabled 5G

III. REALIZING USE CASES WITH MEC

In order to facilitate the requirements of the use cases proposed in Section II, an IBS with MEC capability is ideal considering its dynamic service provisioning capability. Since the MEC platform is locally deployed, the medical services can be classified as local and remote operations. The local services as in Use Case 1, are operating without the core network connectivity. This section is presenting a MEC based edge platform architecture implemented in a hospital environment to achieve the requirements demanding from the use cases mentioned above. Fig. 2 presents the high-level architecture of the MEC edge platform that is formed in accordance to the ETSI standards.

A. AR based Remote Robotic Monitoring with MEC

As indicated in the Fig. 2, AR Robots or AR bots proposed under this use case are controlled via the MEC edge platform that is deployed with a 5G radio BS within the hospital vicinity. This AR robot controlling platform is interfaced by a control station in which the users are operating the AR bots. The remote connectivity between the robots and the control station is established through the MEPM. MEPM, in accordance to the requirements of the AR bot to be launched (depending on the requirements of services out of decontamination, logistics, or interacting with the patients), will request the Virtualization Infrastructure Manager (VIM) to form a Virtual Machine (VM) with intrinsic resources to handle a single AR bot. These AR bots will be embedded with 5G radio transceivers to enable wireless and rapid communication with the IBS.

The Mobile Edge Host (MEH) formed as a VM, launches the required functions as Mobile Edge Applications (ME Apps), that are governed by the Mobile Edge Platform (MEP). The AR related function of caching, computing, and visualizing are handled by separate ME Apps [16], where the necessary sensory inputs are conveyed through the Robot telemetry service. The key significance of this service in contrast to a typical AR system is its integration of the robotic control system. The robot control station is directly linked to the robot control platform inside the MEH. The design and formation of the robot controlling platform launched as a ME App is relying on the feedback, trajectory planning, control interfacing (Brain computer interface, touch based, or haptic), and telemetry methods. Thus, resource specifications of each MEH might vary from each other. As this service is of localized nature, MEHs controlling the AR bots do not require an Internet connectivity. However, internal network and protocols operating within the MEH should feature dynamism. Therefore, we are proposing light-weight virtualization or containerization for implementing the ME Apps, and the MEP [22].

B. MEC Assisted Smart Medical Data Aggregation/patient monitoring and treatment

The main objective of this use case is to aggregate vital medical information related to COVID-19 patients remotely while retrieving them for diagnosis and treatment in accordance to the WHO protocols and guidelines. Thus, the MEC edge platform should incorporate the storage facilities for medical data. The patient registry, proposed as a MEH with a formidable capacity is linked with the entities of other two use cases and with centralized global Patient Health Record (PHR) server. For diagnosis, both patient vitals and testing results are required. Therefore, a MEH is assigned for storing the patient vitals via a telemetry service connected to devices such as pulse oximeter, ventilator, and smart medical beds. In similar manner, records of medical tests conducted under each patient are stored in another Mobile Edge Service (MES) where the data are aggregated from the medical testing apparatus of CT, ultrasound, X-ray, and PCR. Further, an Audio Video (AV) monitoring services is running on a MEH while it is interfacing with the medical officials through hand held devices. Under the AV monitoring MEH, each patient is monitored with a ME App. The access to the PHR level is dependent on the designation of the health official. The diagnosing MES can access all the health records and registries hosted at different MEHs and the global PHR database. Thus, once a patient is been diagnosed and a treatment plan is finalized, treatments are carried out in the reconnaissance mode with AR bots explicated in Use Case 1.

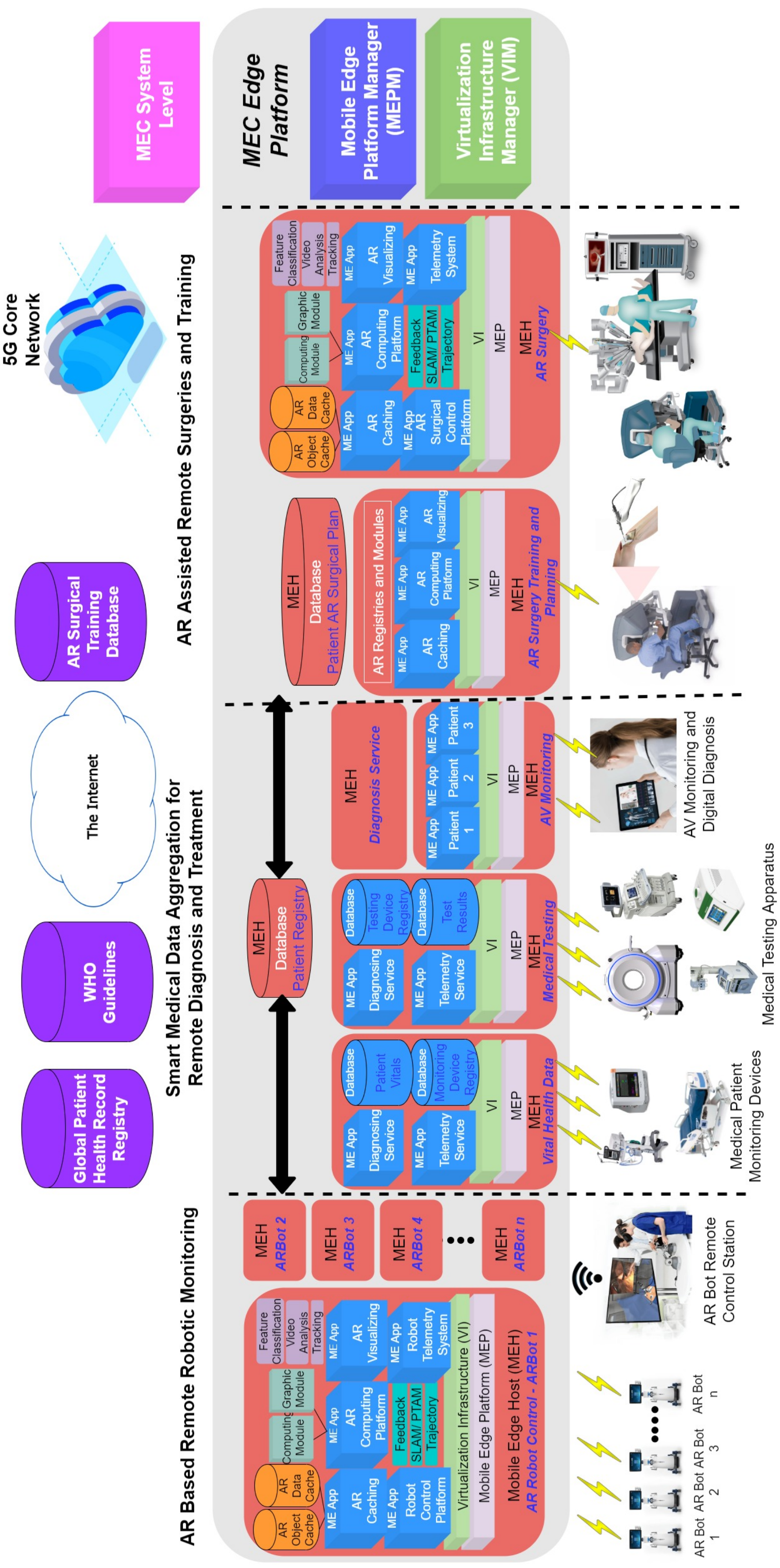


Fig. 2: Realization of Use Cases with MEC

C. AR Assisted Remote Surgery with MEC

With AR, Virtual Reality (VR), and Mixed Reality (MR) technologies, surgeons are given the ability to train and plan all kinds of surgeries beforehand in a virtual environment that emulate the pragmatic circumstances. Thus, use case 3 is inclusive of a training and planning function launched as a MEH and saves the surgical plan to a database; where the surgical attendants can revisit the strategies prior to the surgery. Further, surgical trainees could use this module for training various surgeries available in the AR surgical training database. This function is implemented as a typical AR streaming application in the MES. However, access to the system should be controlled by an internal function. For each AR assisted remote surgery, a MEH is launching the required facilities. The content of the MEH resembles the use case 1, except for the AR surgical controlling platform that links the surgical bed and the remote AR console platform. In order to improve the accuracy and perception of the surgical environment, a Haptic feedback system (such as PHANToM [23]) should be implemented with the surgical controlling function.

IV. FEASIBILITY EVALUATION

We consider two evaluation scenarios to validate our claim of requiring an edge computing platform to realize the above discussed use cases. The results are simulated for latency and scalability aspects for MEC edge scenario considering all 3 Use Cases (UCs), in comparison to an operating environment with cloud computing capabilities. Further, a forecasted expenditure analysis is presented at the end of this section.

Fig. 3 illustrates the model we have considered for conducting the simulations. For the MEC enabled scenario, UE is directly accessing the resources in the edge infrastructure at the IBS in a closer range. In the cloud computing circumstance, UE is reaching the cloud environment or Core Network (CN) through the Access Network (AN) formed by a eNB displaced 1 km from the hospital premises. This eNB is connected to the MEC IBS for catering external connections to the MEC edge. We assume that the link between AN and the CN is established via a Fiber Optic connection of $BW_{AN \rightarrow CN}$ bandwidth spanning to d_{CN} kms. Further, AR based RAS control station is located d_{AR} distance in the same direction towards the CN. The latency associated towards AN to CN, UE to AN, and UE to MEC IBS are denoted as $t_{AN \rightarrow CN}$, $t_{UE \rightarrow AN}$, and $t_{UE \rightarrow MEC}$ respectively. Moreover, we assume that the corresponding devices and processes related to each use case are operating independently during our simulations. The parameters specified in TABLE II are used for conducting the evaluations.

TABLE II: General Simulation Parameters

Parameter	Values
Latency between UE and the MEC IBS: $t_{UE \rightarrow MEC}$	0.25 ms
Latency between UE and the AN: $t_{UE \rightarrow AN}$	1 ms
Latency between AN and the CN: $t_{AN \rightarrow CN}$	0.05ms/km [24]
AR processing delay for UC 1 and UC 3: t_{AR}	30 ms [24]
Audio Video processing delay for UC 2: t_{AV}	20 ms
Distance to the RAS control station in UC 3: d_{AR}	50 km
Bandwidth of the backhaul network $BW_{AN \rightarrow CN}$	10 Gbps
Bandwidth requirement for UC 1: BW_{UC1}	24 Gbps
Bandwidth requirement for UC 2: BW_{UC2}	2 Gbps
Bandwidth requirement for UC 3: BW_{UC3}	30 Gbps
Computing capacity of MEC edge: CPU cycles	5×10^{10} [16]
Computing capacity of the cloud platform: CPU cycles	10^{11} [16]

A. Impact on Latency

In this scenario, end-to-end latency is compared for MEC enabled and disabled instances. Under UCs 1 and 3, AR processes were assumed to be latency critical applications, where the delay associated with processing an AR stream was computed. In UC 3, it is assumed that the RAS control station is located 50 km away from the surgical theatre. For MEC enabled scenario, latency is computed as a combination of $t_{UE \rightarrow MEC}$ and t_{AR}, t_{AV} or $t_{MEC \rightarrow RAS}$ in UC 3. In contrast, for cloud scenario, latency is computed by aggregating t_{AN}, and distance dependent $t_{AN \rightarrow CN}$ apart from processing delays. Thus, Fig. 4(a) indicates the latency associated for each UC for MEC enabled scenario (i.e. highlighted); in contrast to CNs located at

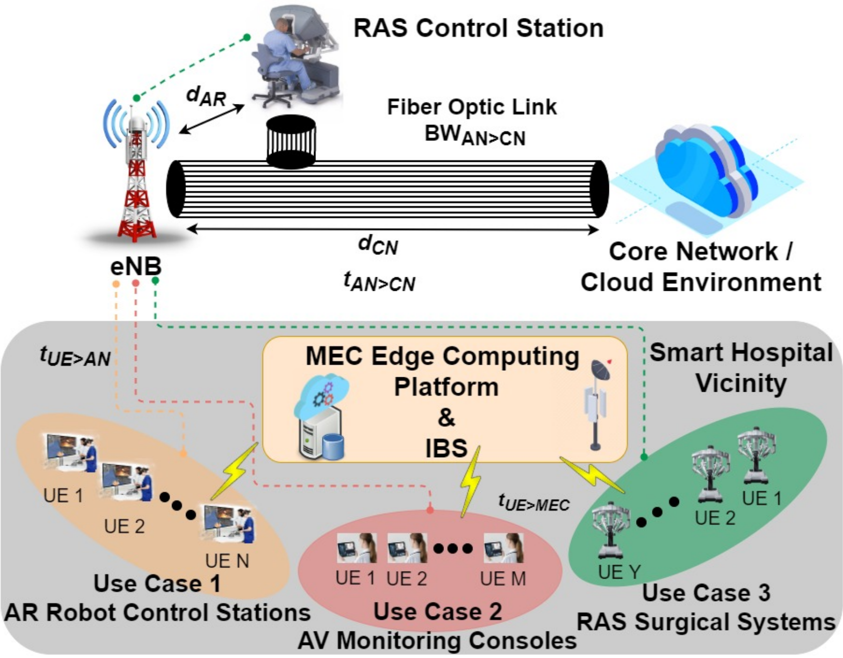
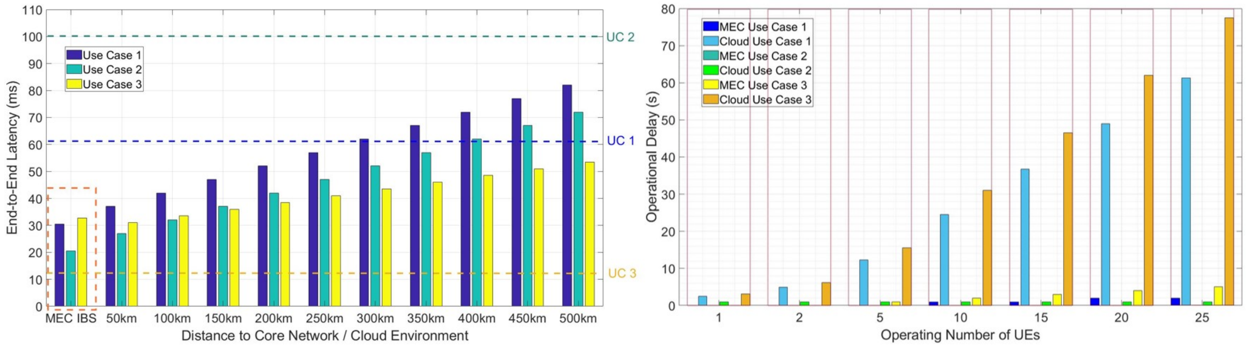


Fig. 3: Model for conducting the simulations



(a) Simulating Latency

(b) Simulating Scalability

Fig. 4: Evaluation of the proposed use cases in the context of MEC adaptability

different distances ranging from 50 km to 500 km. The latency for UC 3 is showing a better result for CNs in close proximity due to the external access of RAS control sequence. Other results however, indicate that MEC based IBS is satisfying the service requirements specified in TABLE I.

B. Impact on Scalability

The operational delay for each use case was computed to validate the feasible adaptability of MEC edge platform under this scenario. The operational delay is inclusive of the transmission and processing delays of an event. We assume the transmission delay is negligible for MEC enabled circumstance. Further, 5×10^9, 3×10^6, and 10×10^9 CPU cycles were assumed as the consuming computing capacity for each use case respectively. Simulation was carried out to determine the operational delay for MEC and cloud computing deployments with the accumulating number of UEs. The operational delay for MEC scenario is computed as a ratio of occupying processing capacity in each use case (for corresponding UEs) to MEC computing capacity. In addition to processing delay with cloud scenario, the delay for transmission computed from specified BW and available $BW_{AN \rightarrow CN}$ is aggregated for operational delay. The simulation is illustrated in Fig. 4(b), where significantly lesser delays are observable for the MEC use cases. The bottleneck created between the eNB and the CN is delaying the whole process at the cloud environment.

C. *Impact on Capital and Operational Expenditure*

In comparison to cloud based deployments, edge deployments require an obvious capital expenditure (capex) to launch the server environment with a IBS. Assuming the MEC edge infrastructure is formed with a server group of 100 TB storage, that can be catered with 3 Dell PowerEdge XR2 Rugged servers which cost around (3,500 x 3) USD [25]. According to [26], launching the MEC IBS that include sector antennas, remote radio units, baseband units, site construction, and power/ battery installments require an approximated total sum of 61,500 USDs. In addition, a backhaul link should be established from the IBS to the nearest intermediary node towards the core network. Assuming this node is located 100 kms from the hospital premises, the expenditure for this link would be 19,000 USDs (cost of 2 routers and the backhaul hub). Thus, capex for launching a IBS within the smart hospital would cost 91,000 USDs (IBS deployment capex = MEC Server cost + Installation cost + Backhaul link cost) in approximation. Though, operational expenditure (opex) for this deployment would be 5,050 USD (Site opex + backhaul opex) per annum [26]. In contrast, initial investment for the cloud service is minimum and depends on the subscription charges.

The subscription for the cloud service is based on the occupying storage and the enrolled computation capacity by each use case. In addition, a cost for the communication/ BW should be bared by the subscriber. We Presume that the subscription for storage is similar for both cloud and MEC scenarios. Thus, in the MEC edge, subscription can be deduced to only the computing cost, as the communication cost is minimal due to the proximate range. We assume 0.75 USD hourly GPU computing cost (10^9 cycles) for cloud services and 0.5 USD for MEC scenario (due to dedicated service); and 0.25 USD of BW cost for 1 Gbps [27]. TABLE III represents the comparison of subscriptions in cloud based and MEC scenarios.

TABLE III: Cost Analysis of launching the use cases with cloud and MEC

	Use Case 1	Use Case 2	Use Case 3
MEC IBS Deployment			
Capex (USD)	91,000		
Opex (USD)	5,050		
Hourly Communication/ BW Cost			
BW Requirement (Gbps)	24.0	2.0	30.0
Cloud Sub.(USD)	6	0.5	7.5
MEC Sub.(USD)	-	-	-
Hourly Computing Cost			
Computing Requirement (CPU cycles)	5×10^9	3×10^6	10×10^9
Cloud Sub.(USD)	3.75	0.0023	7.5
MEC Sub.(USD)	2.5	0.0015	5.0
Total Subscription Charge for an Hour			
Cloud Sub.(USD)	9.75	0.5023	15
MEC Sub.(USD)	2.5	0.0015	5.0
Surplus on MEC Sub.	7.25	0.5008	10.0
Investment Recovery Period	approx. 226 days		

V. DEPLOYMENT CHALLENGES AND SOLUTIONS

In this section, the challenges and limitations related to the proposed MEC implementation are discussed and possible solutions are introduced for improving their feasibility.

A. *Security and Privacy Issues*

Healthcare is an area that requires a formidable level of security and privacy in its IT infrastructure. The sensitivity of PHRs - maintaining doctor-patient confidentiality and protecting the MEC edge data centre from both physical and cyber intrusions that intend for manipulations- are the main objectives for ensuring a secure IT ecosystem in a hospital premises. Further, in the proposed context, due to the higher reliance on time, service impeding attacks that are intended for delaying the services have a higher impact. Thus, securing the communication protocols with proper level of cryptographic primitives is a major requirement.

Possible Solutions: Blockchain is one of the main approaches that researches have employed to ensure privacy and security in healthcare systems. Using Blockchain technology adds a higher complexity towards crypto-analysis, in addition to alleviating the cryptographic overhead on information. Blockchain based enhanced authentication mechanisms and securing methods are promising ways to secure the healthcare environment [28].

B. Communication Issues

The future medical wards and operating theatres are going to be embedded with multitude of sensors and actuators that are controlled via wireless interfaces. This IoT environment that is commandeered by a MEC edge infrastructure as proposed, requires the level of 5G radio communication to satisfy URLLC and eMBB standards. However, IoT devices might not have the capability to embed and serve 5G transceivers due to their high power consumption. In addition, on AR and VR perspective, the motion-to-photone latency that exceed 20 ms for image rendering causes motion sickness for the users as a result of conflicted signals precipitated on vestibulo-occular reflex. This is harmful for AR users in UC 1 and UC 3. Further, the interoperability and the compatibility are challenges that should be addressed to manage scalability.

Possible Solutions: In order to address the limitations on embedding 5G TRXs on IoT devices, Intermediary Access Points (IAPs) that interface 5G radio and other low power communication methods such as Bluetooth low energy and Zigbee; that are common with IoT devices can be deployed. These IAPs would act as a bridge between IoT domain and the edge platform. Launching IAPs provides the ability to scale the miniature sensory devices, while the compatibility issues would be solved on communication perspective.

C. Scalability Limitation

Though MEC is effective for provisioning services with ultra-low latency to a limited coverage area, the available resources in an edge platform are not as rich as in a cloud data centre. MEC concept was introduced to offer specialized services that does not scale up to typical services with higher scalability. Therefore, applications which are consuming and demanding higher resources as in UC 1 and UC 3, MEC is limited to serving the 10th and 1th application instance as specified in TABLE I. Further, in a pragmatic situation where all three proposed use cases are operating simultaneously, load balancing the resources of the MEC platform is an obvious challenge. Thus, a dynamic service provisioning control framework is a prime requirement.

Possible Solutions: Allocation of excessive resources are the only means for mitigating scalability issues. For MEC deployments -if the existing resources are inadequate to launch the services- most recommended method is to append more resources into the system. However, if there is another MEC enabled BS in close proximity, such services can be either migrated to the novel MEC BS, or the content to be processed can be offloaded to it. Further, in an overwhelming situation, MEC BS can offload the service to a cloud platform while balancing the load of its own platform.

D. Legal Adaptation and Ethics

’Robot ethics’, a branch of machine ethics, is a clear application for healthcare robotics that are used in both use cases 1 and 3. Eventhough the robots are human controlled, an intentional or unintentional malfunction would cause harm to human beings that imply ethical and legal repercussions. Thus, robot ethics deal with such dilemmas in a legal context, for the purpose of prioritizing human safety, ensuring superior human command, and protecting the robots’ own existence without inflicting harm to human beings [29]. In the proposed applications, such standards on ethical conduct should be clearly defined and practised as these human-to-machine interactions might create unforeseen conundrums. The user consent is imperative in such a circumstance. Further, aggregation of healthcare data should be pursued in accordance to the EU General Data Protection Regulation (GDPR) standards [30] for ensuring the privacy of patients and health care officials. When a hospital or a medical institute is digitizing their holistic system, a legal framework should be established to govern all the entities within the institutions jurisdiction. All the unspecified legalities regarding the cyber-domain should be contextualized, prior to practicing these novel medical applications since the causes might be quite lethal.

VI. CONCLUSION

Main intention of this article was to emphasize the significance of MEC resembled edge computing platforms for futuristic applications in health care; that would be beneficial in mediating a pandemic situation similar to COVID-19. The proposed use cases are requiring an IT eco-system that optimize the network and computational utilization to novel extents that reach beyond prevailing limitations. Proposed use cases are demanding higher level of specifications. Therefore, it is obvious that the use cases cannot be achieved with an absence of a storage and processing infrastructure in a proximate distance. Thus, the proposed use cases are realizable with MEC platforms deployed within medical institutions. The findings of this research are beneficial for sate-of-the-art medical companies to form an IT infrastructure that launches their applications with featured synergism.

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